Physics Framework

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| Framework number and letter | Big Idea | Essential Question | Concept | Competencies | Standards |
| 1a | Objects that move in translational motion are described in terms of position, velocity, and acceleration. | How can the motion of an object be described in a measurable and quantitative way? | These concepts are used in the design and evaluation of many technologies. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1b | Objects that move in translational motion are described in terms of position, velocity, and acceleration. | How can the motion of an object be described in a measurable and quantitative way? | Vectors allow the formulation of Physical Laws independent of a particular coordinate system. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1c | Objects that move in translational motion are described in terms of position, velocity, and acceleration. | How can the motion of an object be described in a measurable and quantitative way? | The motion of a projectile can be represented and analyzed as two different motions, a vertical motion with constant acceleration and a horizontal motion with constant speed. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1d | Objects that move in translational motion are described in terms of position, velocity, and acceleration. | How can the motion of an object be described in a measurable and quantitative way? | The position, velocity, and acceleration of an object can be measured and quantified (in magnitude and direction), using appropriate tools and units, in a reference frame. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1e | Objects that move in translational motion are described in terms of position, velocity, and acceleration. | How can the motion of an object be described in a measurable and quantitative way? | Position, velocity and acceleration are examples of vectors, quantities relying on both direction and magnitude that combine with other velocity and acceleration vectors according to specific mathematical rules. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1f | Objects that move in translational motion are described in terms of position, velocity, and acceleration. | How can the motion of an object be described in a measurable and quantitative way? | Position, velocity, and acceleration describe the motion of objects at every scale from the motion of subatomic particles to the motion of entire galaxies. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1g | All forces arise from the interactions between different objects. | What is a force? | Four fundamental forces of nature dominate at different scales: the strong and weak forces acting within the nucleus opposing proton-proton repulsion, the electrical force dominates in biological and chemical processes, and gravitational force dominates at astronomical scales. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1h | All forces arise from the interactions between different objects | What is a force? | Coulomb’s Law computes the force between two electrically charged objects at a distance. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1i | All forces arise from the interactions between different objects | What is a force? | Solids, liquids and gases can exert forces on surfaces and is quantified as pressure. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1j | All forces arise from the interactions between different objects | What is a force? | When two surfaces of objects are in contact with each other, the force of friction between them depends on the nature of the materials in contact and the normal force. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1k | All forces arise from the interactions between different objects | What is a force? | Solids, liquids and gases can exert forces on surfaces and is quantified as pressure. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1l | All forces arise from the interactions between different objects | What is a force? | Newton’s Law of Universal Gravitation computes the force between two masses at a distance. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1m | All forces arise from the interactions between different objects | What is a force? | Forces may result from contact or action at a distance in the case of gravitational, electrostatic, or magnetic fields. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1n | All forces arise from the interactions between different objects | What is a force? | Forces may result from contact or action at a distance in the case of gravitational, electrostatic, or magnetic fields. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1o | All forces arise from the interactions between different objects | What is a force? | Four fundamental forces of nature dominate at different scales: the strong and weak forces acting within the nucleus opposing proton-proton repulsion, the electrical force dominates in biological and chemical processes, and gravitational force dominates at astronomical scales. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1p | All forces arise from the interactions between different objects | What is a force? | Coulomb’s Law computes the force between two electrically charged objects at a distance. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1q | All forces arise from the interactions between different objects | What is a force? | When two surfaces of objects are in contact with each other, the force of friction between them depends on the nature of the materials in contact and the normal force. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1r | All forces arise from the interactions between different objects | What is a force? | Newton’s Law of Universal Gravitation computes the force between two masses at a distance. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1s | All changes in translational motion are due to forces. | What causes the motion of an object to change? | While many forces can act on an object, those forces can be represented and analyzed using a free body diagram. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1t | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Given a knowledge of all the forces acting on an object, its accelerations can be calculated. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1u | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Inertial mass is a measure of the resistance of an object to changes in translation motion (Newton’s First Law of Motion). | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1v | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Forces can be mathematically combined together as a vector sum resulting in a single net force that causes the object to accelerate in the direction of that net force. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1w | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Given a knowledge of an object’s motion, its force(s) can be inferred. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1x | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Newton’s Laws of Motion empirically describe the motion of objects in terms of force interactions, mass, and acceleration in a non-accelerating, non-relativistic reference frame. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1y | All changes in translational motion are due to forces. | What causes the motion of an object to change? | An understanding of forces and their interactions is used to describe, explain, and design any number of natural and human-built objects and systems. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 1z | All changes in translational motion are due to forces. | What causes the motion of an object to change? | For objects in a constant state of motion (including those at rest) the net force is zero. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2a | All changes in translational motion are due to forces. | What causes the motion of an object to change? | While many forces can act on an object, those forces can be represented and analyzed using a free body diagram. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2b | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Given a knowledge of all the forces acting on an object, its accelerations can be calculated. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2c | All changes in translational motion are due to forces. | What causes the motion of an object to change? | The inertial mass and charge of an object and any forces acting on it can be measured and quantified using appropriate tools, units, frames of reference, and techniques. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2d | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Forces can be mathematically combined together as a vector sum resulting in a single net force that causes the object to accelerate in the direction of that net force. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2e | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Newton’s Laws of Motion empirically describe the motion of objects in terms of force interactions, mass, and acceleration in a non-accelerating, non-relativistic reference frame. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2f | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Given a knowledge of an object’s motion, its force(s) can be inferred. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2g | All changes in translational motion are due to forces. | What causes the motion of an object to change? | Inertial mass is a measure of the resistance of an object to changes in translation motion (Newton’s First Law of Motion). | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2h | All changes in translational motion are due to forces. | What causes the motion of an object to change? | For objects in a constant state of motion (including those at rest) the net force is zero. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2i | All changes in translational motion are due to forces. | What causes the motion of an object to change? | The inertial mass and charge of an object and any forces acting on it can be measured and quantified using appropriate tools, units, frames of reference, and techniques. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2j | All changes in translational motion are due to forces. | What causes the motion of an object to change? | An understanding of forces and their interactions is used to describe, explain, and design any number of natural and human-built objects and systems. | Construct a free body diagram indicating the magnitude and direction of the forces on an object and use information from the diagram to determine the motion of the object. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 2k | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | A rotating reference frame can give the appearance of an object constrained to travel in a circular path which gives a centripetal acceleration directed from the object toward the center of the rotating reference frame. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 2l | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | The angular position, angular velocity, and angular acceleration of an object are vectors and can be and quantified using appropriate tools, frames of reference, and units in reference to an axis of rotation. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 2m | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | Angular position, angular speed, and angular acceleration are the rotational analogues of translational position, velocity, and acceleration. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2n | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | These terms describe the rotation of objects at different scales from the motion very small particles to the movement of entire galaxies. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2o | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | The angular position, angular velocity, and angular acceleration of an object are vectors and can be and quantified using appropriate tools, frames of reference, and units in reference to an axis of rotation. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2p | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | The rotation of objects gives rise to various rotation-related phenomena including gyroscopic stability and magnetic fields. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 2q | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | A rotating reference frame can give the appearance of an object constrained to travel in a circular path which gives a centripetal acceleration directed from the object toward the center of the rotating reference frame. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2r | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | Angular position, angular speed, and angular acceleration are the rotational analogues of translational position, velocity, and acceleration. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 2s | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | These terms describe the rotation of objects at different scales from the motion very small particles to the movement of entire galaxies. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 2t | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | The rotation of objects gives rise to various rotation-related phenomena including gyroscopic stability and magnetic fields. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2u | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | A rotating reference frame can give the appearance of an object constrained to travel in a circular path which gives a centripetal acceleration directed from the object toward the center of the rotating reference frame. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 2v | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | The angular position, angular velocity, and angular acceleration of an object are vectors and can be and quantified using appropriate tools, frames of reference, and units in reference to an axis of rotation. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 2w | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | Angular position, angular speed, and angular acceleration are the rotational analogues of translational position, velocity, and acceleration. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2x | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | These terms describe the rotation of objects at different scales from the motion very small particles to the movement of entire galaxies. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2y | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | The angular position, angular velocity, and angular acceleration of an object are vectors and can be and quantified using appropriate tools, frames of reference, and units in reference to an axis of rotation. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 2z | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | The rotation of objects gives rise to various rotation-related phenomena including gyroscopic stability and magnetic fields. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3a | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | A rotating reference frame can give the appearance of an object constrained to travel in a circular path which gives a centripetal acceleration directed from the object toward the center of the rotating reference frame. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3b | The rotational motion of objects is described in terms of angular position, angular velocity, and angular acceleration. | How can rotational motion be described in a measurable and quantitative way? | Angular position, angular speed, and angular acceleration are the rotational analogues of translational position, velocity, and acceleration. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3c | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | The rotational mass/inertia of an object and the torques acting on it can be measured and quantified using appropriate tools, units, and techniques. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
|  | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An object in equilibrium has vector sums of torques and forces both equal to zero. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 3d | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | Torque is vector product of an applied force and the distance between the application and an object’s axis of rotation, resulting in the rotation of the object. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 3e | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | Torque is the rotational analogue of force for translational motion. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 3f | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | These concepts explain phenomena at different scales from particle interactions to galaxy formation. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 3g | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | Torque is vector product of an applied force and the distance between the application and an object’s axis of rotation, resulting in the rotation of the object. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3h | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | Torque is the rotational analogue of force for translational motion. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3i | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An understanding of these concepts is used to describe, explain, and design any number of natural and human-built objects and systems. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 3j | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An object’s rotational inertia is determined by the object’s mass distribution around the axis of rotation, analogous to mass for translational motion. Consequently, two objects with identical total masses but different mass distributions will have different rotational inertias. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3k | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | The rotational mass/inertia of an object and the torques acting on it can be measured and quantified using appropriate tools, units, and techniques. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3l | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | Torque is vector product of an applied force and the distance between the application and an object’s axis of rotation, resulting in the rotation of the object. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3m | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | These concepts explain phenomena at different scales from particle interactions to galaxy formation. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3n | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | The rotational mass/inertia of an object and the torques acting on it can be measured and quantified using appropriate tools, units, and techniques. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3m | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An object’s rotational inertia is determined by the object’s mass distribution around the axis of rotation, analogous to mass for translational motion. Consequently, two objects with identical total masses but different mass distributions will have different rotational inertias. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3n | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An object in equilibrium has vector sums of torques and forces both equal to zero. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3o | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An understanding of these concepts is used to describe, explain, and design any number of natural and human-built objects and systems. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 3p | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An object’s rotational inertia is determined by the object’s mass distribution around the axis of rotation, analogous to mass for translational motion. Consequently, two objects with identical total masses but different mass distributions will have different rotational inertias. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 3q | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | Torque is the rotational analogue of force for translational motion. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3r | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | These concepts explain phenomena at different scales from particle interactions to galaxy formation. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3s | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An object in equilibrium has vector sums of torques and forces both equal to zero. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3t | All changes in rotational motion are due to torques. | What causes changes in the rotational motion of an object? | An understanding of these concepts is used to describe, explain, and design any number of natural and human-built objects and systems. | Calculate the torque acting on an object using the rotational inertia and angular acceleration of the object. |  |
| 3u | Objects that move in simple harmonic motion can be described in terms of position, velocity, and acceleration and can result in the production of waves that travel through space. | How can the periodic motion of objects be described? | The waves produced by objects in simple harmonic motion interact with other waves and matter and result in the phenomena of wave superposition, interference, reflection, refraction, and resonance. | Describe the relationship between simple harmonic motion and the formation of waves and related phenomena. |  |
| 3v | All changes in rotational motion are due to torques. | How can the periodic motion of objects be described? | These concepts are used in the design and evaluation of many technologies. | Describe the relationship between simple harmonic motion and the formation of waves and related phenomena. |  |
| 3w | Objects that move in simple harmonic motion can be described in terms of position, velocity, and acceleration and can result in the production of waves that travel through space. | How can the periodic motion of objects be described? | Mechanical and electromagnetic waves are described in terms of wavelength, amplitude, velocity, and frequency and can be produced by objects in simple harmonic motion or electrical circuits. | Describe the relationship between simple harmonic motion and the formation of waves and related phenomena. |  |
| 3x | All changes in rotational motion are due to torques. | How can the periodic motion of objects be described? | Traveling waves transfer energy exerted as force to distant objects that absorb or reflect the traveling waves. | Describe the relationship between simple harmonic motion and the formation of waves and related phenomena. |  |
| 3y | Objects that move in simple harmonic motion can be described in terms of position, velocity, and acceleration and can result in the production of waves that travel through space. | How can the periodic motion of objects be described? | The period, frequency, amplitude, position, velocity, and acceleration of an object in simple harmonic motion can be measured and quantified (in magnitude and direction), using appropriate tools and units, in a reference frame. | Describe the relationship between simple harmonic motion and the formation of waves and related phenomena. |  |
| 3z | All simple harmonic motion can be explained using force and/or torque. | What causes an object to oscillate instead of moving off in a straight line? | The return force or torque tries to return the inertial mass to the resting position while the internal mass resists changes in motion. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4a | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | Inductance is the electrical analog for inertial mass, and capacitance is the electrical analog for a returning force. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4b | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | The simple harmonic motion of an object can be quantitatively described using the sine and cosine trigonometric functions. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4c | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | The inertial mass and return force or torque of objects interacting in a system can be measured and quantified using appropriate tools, units, and techniques. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4d | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | Solids, liquids and gases behave as springs providing restoring force when displaced from equilibrium. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4e | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | The simplest harmonic motion can be characterized by one part, an inertial mass, that remains in one vicinity while oscillating about an average position. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4f | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | Simple harmonic oscillators can be constructed out of inductors and capacitors to generate electromagnetic waves. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4g | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | These concepts are used in the design and evaluation of many technologies. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4h | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | The oscillatory behavior results from the interplay of two properties that have opposite tendencies: a return force or torque and an inertial mass. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4i | All simple harmonic motion can be explained using force and/or torque | What causes an object to oscillate instead of moving off in a straight line? | The angular frequency of oscillation is related to the return force and inertial mass. | Using conservation of angular momentum, calculate the changes in an objects angular velocity as its rotational inertia changes. |  |
| 4j | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In an isolated system, the total momentum or angular momentum is conserved. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4k | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In every transformation of energy from one form to another, some of the energy is converted into thermal energy. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4l | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The conservation laws apply at all scales from very small particles to entire universe. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 4m | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The rotational inertia and angular velocity of an object can be represented in terms of its angular momentum and kinetic energy. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4n | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In a closed system, the product of an object’s angular speed and rotational inertia will remain constant. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4o | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The kinetic energy of an object in simple harmonic motion is at its minimum value when the object is at its maximum displacement and at its maximum when the object passes through its equilibrium position. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 4p | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The total amount of energy in a closed system is conserved. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4q | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The position and velocity of an object or interacting objects can be represented and quantified in terms of its momentum, angular momentum, kinetic energy, and potential energy. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 4r | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In an isolated system, the total momentum or angular momentum is conserved. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 4s | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | There are a number of situations in which an object will have both translational and rotational kinetic energy. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4t | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | Rotational kinetic energy is the rotational analogue of translational kinetic energy. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 4u | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The kinetic energy of an object in simple harmonic motion is at its minimum value when the object is at its maximum displacement and at its maximum when the object passes through its equilibrium position. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4v | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In every transformation of energy from one form to another, some of the energy is converted into thermal energy. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 4w | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The rotational inertia and angular velocity of an object can be represented in terms of its angular momentum and kinetic energy. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 4x | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The conservation laws apply at all scales from very small particles to entire universe. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4y | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In a closed system, the total work performed by objects may be calculated from the final kinetic energy minus the initial kinetic energy. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 4z | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The total amount of energy in a closed system is conserved. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 5a | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The potential energy of an object in simple harmonic motion is at its maximum value when the object is at its maximum displacement and at its minimum when the object passes through its equilibrium position. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 5b | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | There are a number of situations in which an object will have both translational and rotational kinetic energy. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 5c | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The kinetic energy of an object in simple harmonic motion is at its minimum value when the object is at its maximum displacement and at its maximum when the object passes through its equilibrium position. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 5d | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The total amount of energy in a closed system is conserved. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5e | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The position and velocity of an object or interacting objects can be represented and quantified in terms of its momentum, angular momentum, kinetic energy, and potential energy. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5f | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In a closed system, the product of an object’s angular speed and rotational inertia will remain constant. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 5g | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In a closed system, the total work performed by objects may be calculated from the final kinetic energy minus the initial kinetic energy. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 5h | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The potential energy of an object in simple harmonic motion is at its maximum value when the object is at its maximum displacement and at its minimum when the object passes through its equilibrium position. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 5i | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | Rotational kinetic energy is the rotational analogue of translational kinetic energy. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5j | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The conservation laws apply at all scales from very small particles to entire universe. | Use information from the various representations of translation motion to solve for unknown motion quantities of objects in translational motion. | [S11.A.1.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27286?cf=y ), [S11.A.3.3.3](http://www.pdesas.org/Standard/StandardsBrowser#27322?cf=y ), [S11.C.3.1.4](http://www.pdesas.org/Standard/StandardsBrowser#27378?cf=y ), [S11.D.3.1.1](http://www.pdesas.org/Standard/StandardsBrowser#27402?cf=y ) |
| 5k | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In every transformation of energy from one form to another, some of the energy is converted into thermal energy. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5l | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The rotational inertia and angular velocity of an object can be represented in terms of its angular momentum and kinetic energy. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5m | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In a closed system, the product of an object’s angular speed and rotational inertia will remain constant. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5n | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In a closed system, the total work performed by objects may be calculated from the final kinetic energy minus the initial kinetic energy. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5o | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | Rotational kinetic energy is the rotational analogue of translational kinetic energy. | Calculate the work done by a drum rolling down an inclined plane. |  |
| 5p | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The potential energy of an object in simple harmonic motion is at its maximum value when the object is at its maximum displacement and at its minimum when the object passes through its equilibrium position. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5q | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | In an isolated system, the total momentum or angular momentum is conserved. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5r | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | There are a number of situations in which an object will have both translational and rotational kinetic energy. | Use conservation of energy to calculate the kinetic energy and potential energy of an object at any time during its motion. |  |
| 5s | All motion can be explained using the laws of the conservation of energy, the conservation of momentum, and/or the conservation of angular momentum. | How do an object’s mass distribution and interactions with other objects and forces at a distance influence the object’s motion? | The position and velocity of an object or interacting objects can be represented and quantified in terms of its momentum, angular momentum, kinetic energy, and potential energy. | Calculate the work done by a drum rolling down an inclined plane. |  |